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DAWN OF THE ELECTRONICS AGE

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THE STORY OF PALO ALTO AND ITS NEIGHBORS

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October, 1955

Daily Palo Alto Tim

MEMBER ASSOCIATED PRESS

PALO ALTO, CALIFORNIA WEDNESDAY, APRIL 30, 1919

TWENTY-SEVENTH YEAR

Latest News

DR. NORTHCOTT OUT ON BAIL

GREATEST RADIO ACHIEVEMENTS OF WORLD WORKED OUT IN THE PLANT IN PALO ALTO

Dramatic Story of Revolutionary Developments in Radio Transmission Told for the First Time — Federal Telegraph Company, Manned by Stanford Engineers, Works Out High Powered Arcs Held to Be Impossibility — Nine-foot

DAILY PALO ALTO TIMES THURSDAY, SEPTEMBER 22, 1955

'ERMA' WILL MAKE BANK BOOKKEEPING EASY

SRI unveils new super-electronic device

By GLENN BROWN
Times Business Editor

Stanford Research Institute yesterday announced the birth of Erma, an electronic "whiz kid" weighing more than 25 tons and apparently destined to revolutionize bank bookkeeping and accounting.

ERMA is short for Electronic Recording Machine Accounting. SRI developed ERMA for Bank of America. The two organizations teamed up to proudly remove the wraps from their frisky robot bookkeeper for some 40 newsmen in Menlo Park yesterday.

S. Clark Beise, bank president, calls ERMA "the biggest advance in bank-account bookkeeping" in the history of the industry. And here's why:

ERMA takes coded checks or deposit slips and sorts them at the rate of 10 per second according to account numbers. Checks are thereby readied for attachment to the monthly statements.

Effect of this "electronic brain" on the banking industry, which has become increasingly mired in bookkeeping and secretarial tape for all the refer-

they don't expect ERMA to bring about widespread layoffs. Rather, they said, personnel hound by tedious detail work would be relieved to "make other ... service available to people."

When the bank contracts with SRI five years ago for development of a machine

Federal Telegraph Company two-house laboratory and shed factory, 1909-16, where in 1912 de Forest, Logwood, and Van Etten developed the Audion Amplifier and Oscillator. (Photo courtesy Electrical Communications)

PALO ALTO HISTORICAL ASSOCIATION
Founded 1948

Peninsula Electronics---Industry and Research

San Bruno
- Eitel-McCullough, Inc.

San Mateo
- Radio Station KEAR
- Radio Station KVSM

Belmont
- Specialized Instruments Corporation
- Thermo Instrument Company

San Carlos
- Beckman and Whitley, Inc.
- Color Television Incorporated
- Dalmo Victor Company
- Electronic Engineering Associates
- Lenkurt Electric Company
- Litton Industries
- Sierra Electronic Corporation
- Varian Associates, Inc.

Redwood City
- Ampex Corporation
- Carad Corporation
- General Electric Assembly Plant
- K-F Development Company
- Levinthal Electronic Products
- Raycon Corporation

Menlo Park
- Bella Engineering Company
- Cronin Associates
- Harworth Manufacturing Company
- Huggins Laboratories, Inc.
- Jobbins Electronic Enterprises

Palo Alto
- Admiral Corporation Laboratory
- Alto Scientific Company, Inc.
- Bennett Products Manufacturing Company
- Fisher Research Laboratories, Inc.
- General Electric Microwave Laboratory
- Hewlett-Packard Company
- Johnson-Williams, Inc.
- Kaar Engineering Company
- Kaiser Aircraft & Electronics Corporation
- KIBE-Sundial Broadcasting Corporation
- Mackay Radio and Telegraph Company
- Pacific Telephone and Telegraph Company
- Palo Alto Engineering Company
- RS Electronics Corporation
- Stanford Research Institute
- Stanford University
  - Applied Electronics Laboratory
  - Electronics Research Laboratory
  - W. W. Hansen Laboratories of Physics
  - High Energy Physics Laboratory
  - Microwave Laboratory
  - Harris J. Ryan High Voltage Laboratory
- Radio Station KZSU
- Thor Transformer and Electronics, Inc.
- Varian Associates, Inc.
- Western Coil Products, Inc.

Los Altos
- Electronics Processes Corporation

Mountain View
- Sylvania
  - Electronics Defense Laboratory
  - Microwave Tube Laboratory
- O'Dell Brothers

Sunnyvale
- Gudeman Company of California, Inc.
- Illumi Tronic Engineering Company

Los Gatos
- Cascade Research Corporation
- Lewis and Kaufman, Ltd.

Santa Clara
- Dalmotor Company

San Jose
- International Business Machines Corporation
- Jennings Radio Manufacturing Company
- Radio Station KEEN
- Radio Station KLOK
- Radio Station KSJO
- Radio Station KXRX
- Television Station KNTV

Dr. Lee de Forest, inventor of key three-electrode Audion Tube in 1906 (left)

Charles V. Logwood, ingenious technician and member of famed 1912 discovery team (right)

Herbert Van Etten, telephone company engineer, third member of the 1912 research trio in Palo Alto (inset)

1908-1955

Radio, Radar, Television

Electronics Era

Began in Palo Alto

An Adventurous Time of Miracles

Electronics is Returning West to its starting-point in Palo Alto.

From today's threshold of the Electronics Age our focus swings past the nation's 8-billion-dollar electronics field, third largest industry in America, to the West's 18 percent of the country's electronics and the Peninsula's estimated $360 million yearly business employing well over 11,000 workers. With over 23 percent of all U.S. engineers and scientists engaged in electronics (more than any other specialty, including aeronautics, medicine, and chemistry), the local projection of fast-growing electronics to over a billion dollars for the Peninsula by 1965 suggests an amazing future.

Actually, 54 electronics firms are located in the area south from San Francisco through San Jose, with the greatest concentration in the industrial hub around Stanford University.

Local yardstick for industrial electronics shows:

Johnson-Williams—$200,000 annual gross.

Bennett Products Manufacturing Company—$500,000 yearly production.

Fisher Research Laboratories—over $700,000 annual output.

Kaar Engineering — approximately $1 million yearly production.

Varian Associates—$7 million business volume.

Hewlett-Packard—over $15 million yearly yield.

General Electric Company has located one of its three major U.S. laboratories in Stanford's Industrial Park where also **Admiral Corporation** is beginning construction of its $300,000 investment in research laboratory and equipment.

Manufactured in the United States of America
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Cyril F. Elwell, pioneer engineer in radio-telegraph research and long-distance communications systems; founder of electronics firms here and abroad.

Cyril F. Elwell, earliest electronics pioneer, organizer of Palo Alto's historic 1912 electronics research team of de Forest, Logwood, and Van Etten, lives in Los Altos and is still active in research. Dr. Frederick E. Terman, dean of engineering and provost at Stanford University, has been the inspiration of many young scientists in electronics.

In 1948, an ex-Palo Altan, Dr. William Shockley, jarred the public and the scientific world with his announcement of the astonishing pea-sized Transistor which may supplant radio's vacuum tube. Its punch strengthens weak electrical impulses by a hundred thousand times! Other experiments here are bouncing communication signals off meteor trails high in the stratosphere. . .

So—the Palo Alto Story salutes this bewildering new giant of laboratory and industry—ELECTRONICS!

Elwell, an American boy from Australia, worked his way across on a ship and arrived in Palo Alto in November, 1902. After preparatory

studies under Schoolmaster J. L. Dixon of Manzanita Hall, he won his degree from Stanford and did graduate work in metallurgy under Prof. Dorsey A. Lyon and Dr. G. H. Clevenger. A promising career job with Noble Electric Steel Company was interrupted when Dr. Harris J. Ryan recommended "Cy" as a radio specialist to investigate patents for Oakland bankers. This gave purpose to Elwell's first radio-telephone research with an experimental aerial wire stretched from the dome of the earthquake-damaged Stanford Library. But University Trustee Timothy Hopkins was somewhat less than sympathetic. "He ordered me off the campus," Elwell recalls.

Having moved to 1451 Cowper Street, Elwell built there in Palo Alto in 1908, the first radio-telephone station on the West Coast. This he equipped with a pair of 75-foot masts and an aerial strung to the Palo Alto Water Works tower. Later, his wavering broadcast of "Blue Danube Waltz" from "Station Elwell" to Mountain View and Los Altos proved five-mile radio communication possible. This awkward, static-harassed, broken-voiced system, the invention of San Francisco's 16-year-old Ignatius McCarty, was based on Marconi's "damped" intermittent-waves method.

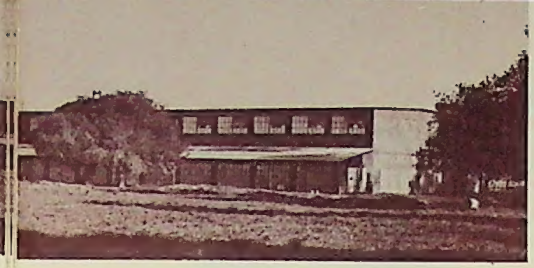
Needing Danish inventor Valdemar Poulsen's arc generator (1903) for continuous-wave transmission and reception, Elwell secured a sample arc generator from Copenhagen and, with the financial backing of Dr. David Starr Jordan and Stanford faculty members, including Professors Charles D. Marx, L. M. Hoskins, and others,

At 1451 Cowper Street, Palo Alto, home-lab for 1908 "Station Elwell;" equipped with two 75-foot wooden masts for his aerial.

Large Federal Telegraph Company plant, 1917-32, on El Camino Real, Palo Alto, where Poulsen Arc Converters and station equipment were manu-

he founded in 1909 the Poulsen Wireless Telephone and Telegraph Company. Elwell, as president and chief engineer of the firm (later the Federal Telegraph Company), demonstrated the Poulsen system with broadcasts from the barn station of Roland Marx at 357 Kingsley to an aerial on Lytton Avenue. In 1910 he demonstrated a 50-mile two-way continuous-wave transmission from 180-foot masts in Stockton and Sacramento, with conversation between Dr. Jordan and the respective town mayors. A third station, on the San Francisco beach, with 300-foot wooden masts designed by Prof. Charles B. Wing of Stanford, guyed with old Geary Street cable-car cables, presented a three-station radio-telephone demonstration which silenced critics but left unsolved basic problems of longer-distance transmission and static-clear reception.

Engineer Cyril Elwell had spent a strenuous four years just prior to launching the historic research team in 1911-12. His pioneer radio-telephone experimental station at 1451 Cowper Street, Palo Alto, led to his trip to Copenhagen and return with an option on Poulsen Arc Converter patents for the U.S.A. in 1909. He had built three stations and demonstrated radio-telephony over the 50-80-mile triangle of the Stockton, Sacramento and San Francisco stations the following year. And in 1910, as chief engineer of the Poulsen Wireless Telephone and Telegraph Company, he developed a chain of 18 high-power radiotelegraph stations in this country with all of the equipment being manufactured in Palo Alto at 913 Emerson Street (Federal Telegraph's El Camino plant wasn't built until 1916). Then in 1912 Elwell opened commercial communication between San



factured for communications systems installed in the Americas, Asia, and Europe, employed 300 personnel at World War I peak production in 1918

Francisco and Honolulu—longest communication line at that time—2,400 miles.

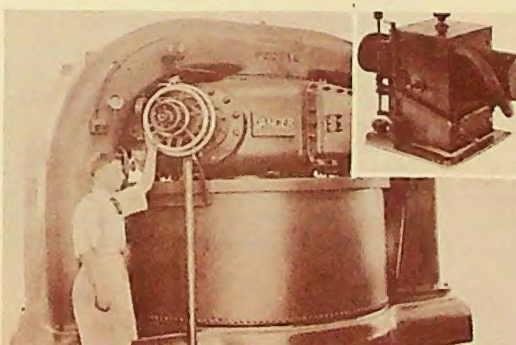
Elwell employed a team of three men to work for Federal Telegraph in the small laboratory-factory at 913 Emerson and next door at 218 Channing Avenue. Here, and in the enlarged backyard shed, worked Elwell's radio discovery team, headed by Dr. Lee de Forest, inventor in 1906 of the famed three-electrode Audion Tube, and later recipient of the 1946 Edison Medal for "pioneering achievements in radio." In his third autobiography, "Father of Radio" de Forest lists 204 patents in electronics. He stayed here a year with his mother, Mrs. Anna R. de Forest, widow of a Congregational minister, and long-time local resident on Kellogg Avenue. The inventor's second cousin, Albert Lee de Forest, former president of Columbia Steel Company, lived at 950 University Avenue where, as a zealous Stanford football fan, he once startled his wife by inviting the entire team and coaching staff over for dinner. Dr. de Forest's third cousin, Mrs. Allen (Marie) Emery, a voice teacher at Castilleja School, lives at 648 North California Avenue. Today Dr. de Forest, now 82, resides with his third wife (former film actress Marie Mosquini) in North Hollywood.

Two resourceful experimenters played a key role in discovering historic adaptations of de Forest's Audion Tube here. They were brilliant young Charles V. Logwood, radio "ham" from San Luis Obispo, and engineer Herbert Van Etten, a Stevens Institute of Technology graduate and formerly with the New York Telephone Company. Van Etten left in 1913 to join the Pacific Telephone and Telegraph Company, remaining until his recent retirement. His parents, the M. M. Van Ettens, moved to Palo Alto in 1906; his sister, Miss Ilza Van Etten (Stanford, '15), was a teacher; and a brother, H. P. "Deacon" Van Etten (Stanford, '09), was a state hydraulic engineer.

Throughout the summer and fall of 1912 numerous experimental hookups by the team finally resulted in Logwood's demonstrating the Audion Tube's amplification which de Forest had predicted. They soon had the tube's 120-times-amplification making a watch tick "clack" across the little lab and a fly's footsteps on a sheet of drawing paper sound like marching boots. Dr. de Forest, the enthusiastic dreamer, and Logwood, the alert technician, were in close collaboration as a team with Van Etten, the analyst and skeptic, when Van Etten chanced on a hookup of the audion tube which amazed them with clear signals from the Company's beach station in San Francisco. The tube oscillated and all was duly sketched by Van Etten in his and de Forest's notebooks (important evidence for later court controversy by Armstrong and others). All three shared in the close experimental work of 1912 which produced the oscillating audion and amplifier, launching the electronic age.

Others associated with Elwell in 1912-13 besides Van Etten, de Forest and Logwood, included Douglas Perham, Leonard F. Fuller, E. S. Pridham and Peter Jensen. The latter

One of two huge 1,000-kw Arc Converters built by Federal Telegraph Co. in Palo Alto in 1918--21 (one given to Stanford University, the other to University of California). Inset shows original little Danish Poulsen Arc Converter used here in 1909 demonstration for funds. (Photo courtesy Electrical Communications)



two engineers later developed the Magnavox loudspeaker, spreading the public address system throughout the country. On several trips East, de Forest sold rights for the two developments to American Telephone and Telegraph Company for $140,000. The Federal Telegraph Company here retained shop rights.

Having pioneered long-distance communications systems for the first Poulsen Wireless Telephone and Telegraph Company (1910-12), linking its Chicago, Seattle, and San Francisco network stations with Honolulu, Elwell resigned in 1913 and left for a career in Europe. He became chief engineer of the British Universal Radio Syndicate; he founded and for 28 years was director of the noted Mullard Radio Valve (tube) Company in England. He is now a special consultant for the Hewlett-Packard Company.

When Elwell left the firm, reorganized now as the Federal Telegraph Company, Leonard F. Fuller was promoted to chief engineer. He began designing Poulsen converters from 2-kilowatt to 1,000-kilowatt giants as Federal established a factory employing 300 workers near the Stanford campus. Large Army and Navy contracts of World War I boomed production as arc converters were sold and installed at many transmitting stations, including the world's largest transmitter, the 1,000-kilowatt Lafayette Station at Bordeaux, France. Big installations were placed in Alaska, Hawaii, the Philippines, San Diego, the Panama Canal Zone, Puerto Rico, the Gulf Coast and Annapolis. Many small converters were placed on American battleships and cruisers. One contract alone called for converters on 300 merchant vessels (World War I Liberty ships).

Two of the huge 1,000-kilowatt arc converters built in Federal's big plant on El Camino (later acquired by the city as a corporation yard and used for a while by United Helicopters) were left over from World War I and stored as surplus. One was given to the University of California in 1931 and used in the first historic 42-inch

Dr. Leonard F. Fuller, Federal Telegraph Company chief engineer, developer of big Poulsen Arcs. He operated relay connected with South San Francisco and Tuckerton, New Jersey, stations linked with White House when President Woodrow Wilson pressed the golden key starting pump and fountain by the tower of jewels opening the 1915 Panama Pacific International Exposition.

atom-smashing cyclotron designed by Dr. Ernest O. Lawrence as the forerunner of even larger cyclotrons in the United States atomic research program. The other converter was earmarked for Stanford University, but gathered dust until Palo Alto sold it for junk to Japanese agents collecting metal prior to World War II!

Leaving Federal Telegraph Company, Dr. Fuller in 1919 with former Federal colleague Colin B. Kennedy founded the Colin B. Kennedy Company in San Francisco for production of radio-broadcast receivers. This firm operated one of the earliest vacuum-tube broadcasting stations in the West at a small station located in the barn of Emil A. Portal's home (the old Auzerais place) in Los Altos. Later, in 1921-22, Dr. Fuller pioneered the art of telephoning over high-voltage (220,000-volt) power lines, linking major electric power sub-stations in the Bay Area with hydroelectric power plants 200 miles away on the Pitt and Feather rivers.

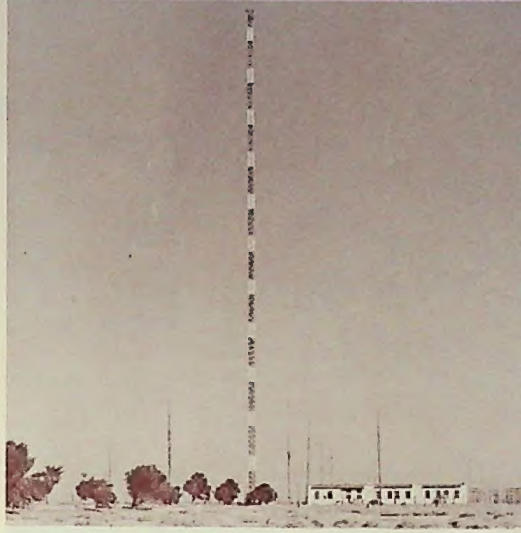
In 1927 International Telephone and Telegraph's American subsidiary, the Postal Telegraph-Commercial Cables group, established the Mackay Radio and Telegraph Company which purchased the Federal Telegraph Company's Western interests, includ-

ing the big El Camino plant and the Marsh Station built on Bayshore in 1920. Mackay enlarged the Marsh Station in 1928, and again in 1935, where the 626-foot antenna mast spreads its umbrella of guys and cables over the pole-cluttered "antenna farm." Its 25 transmitters, now directed by Sidney N. Burton, effect point-to-point range across the Pacific at 2,000- to 50,000-watt strength. Federal Telegraph Company completed its move to Newark, New Jersey, in 1932. Shortly after this Dr. Fuller, who had returned to Federal in the late 'twenties as executive vice-president, became head of the Electrical Engineering Department of the University of California. In 1943 he went as chief engineer to the Joshua Hendy Iron Works (now Westinghouse) at Sunnyvale. Following World War II, he joined the Stanford University Electrical Engineering faculty and served as co-ordinator of Contract Research until his retirement in 1954.

THE TELEPHONE

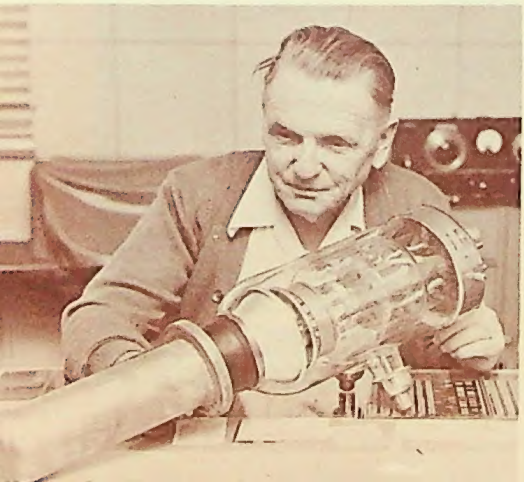
The communications chapter of electronics also embraces the wire-line telephone and radio broadcasting. A line of spindly wooden poles along the dusty road past oak-dotted countryside, which was later to be Palo Alto, held the single telephone wire connecting San Jose with San Francisco 70 years ago. The first long-distance line in the West, and one of the first in the world, foreshadowed the telephone service in Palo Alto. The town had nearly 300 people when the first telephone office was opened in J. F. Parkinson's lumber office on Alma Street in August, 1892, when he was appointed local agent for the Sunset Telephone and Telegraph Company. A public phone was available in his store. The next year a 30-line wall-type switchboard was operating in Parkinson's new office on Emerson Street (present Buick garage site). A state telephone directory of 1896 lists three local subscribers — Morris & Hershon, real estate; J. Farmin & Company, butchers; and Parkinson Lumber and Hardware Company.

In 1896, B. F. Hall took over the telephone agency in his drugstore at University and High Streets (former Wilson restaurant location). Three years later the phone directory for California, Washington, and Oregon had 70 Palo Alto listings. More business brought a separate office by 1901, located beside Smith's Cyclery on the Circle, under the new name of Pacific States Telephone and Telegraph Company. Later moves placed the little telephone office on High Street near University Avenue in 1907, the old



Mackay Radio and Telegraph Co. Marsh Station built in 1920, with 626-foot steel mast rising above the 500-pole 350-acre antenna farm flanking Bayshore

Sidney N. Barton joined Federal Telegraph in 1917 and continued with Mackay Radio and Telegraph Co. since its operation of the Marsh Station after 1927. As manager of the station, he is showing an F124 50,000-watt water-cooled vacuum tube in this 1954 photo



Palo Alto Telephone Office in B. F. Hall's drug-store in 1896. Ernest T. Becker, inset, has record of 43 years employment term with telephone company here.

Chamber of Commerce location at 449 Ramona Street the following year, and thence to Hamilton Avenue, where the office remained until completion of the $300,000 two-story Pacific Telephone and Telegraph Company building at 529 Bryant Street in 1929, the year dial phones were installed.

Ernest T. Becker, supervising wire chief, has been with the firm more than 40 years. According to Business Office Manager J. E. Gordon, the 16,000 calls handled daily by the Palo Alto exchange in 1952 have now increased to 20,000 calls. Over 500 employees operate the modern three-building plant, representing an $11-million investment.

The third phase of electronics communications, radio broadcasting, has expanded notably. Peninsula radio broadcasting stations south of San Francisco include KVSM and KEAR in San Mateo, KIBE of Palo Alto, and KEEN, KLOK, KSJO, and KXRX of San Jose. Stanford University Station KZSU has operated on the campus since 1946 as a "wired-radio" broadcasting system for the Stanford campus.

Although the friendly, gay personality of "Corrie" Burdick, the colorful Dr. Kate of radio drama, made "modern-day" Palo Altans conscious of their own community on the air via the local outlet of San Jose's Station KEEN shortly after World War II, Station KIBE (many years after "Station Elwell") has been the truly local radio station. Pioneered by Millard Kibbe in 1949, Station KIBE was sold to J. B. Rhodes a year later, and resold in 1953 to Edward Davis. Linked with his FM Station KDFC in Sausalito in the KIBE-Sundial Broadcasting Corporation, its local transmitter is located near University Avenue and Bay Road, East Palo Alto.

STANFORD LABORATORIES AND GARAGE LABS

In unpretentious ways, electronics research and industry grew up together in the Stanford-Palo Alto area, some cradled by Stanford research, others originating from humble beginnings in garage "labs." Among highlights in the 47-year history of electronics here, one might list the following:

1908 (Elwell) Radio-Telephone station, 1451 Cowper Street, Palo Alto.

1912 (Van Etten, de Forest, Logwood) Audion Amplifier.

Prof. Harris J. Ryan, world authority on high-voltage transmission, who had above his office an early-day attic "communications lab" where electronics at Stanford had its start.

1912 (Logwood, de Forest, Van Etten) Audion Oscillator.
1915 (Fuller) High-Power Federal-Poulsen Arc Transmitter.
1929 (Fisher) M-Scope.
1937 (Kaar) Mobile Two-way Radio Telephone.
1938 (Hewlett) Resistance Capacity Audio Oscillator.
1939 (Russell and Sigurd Varian) Klystron.
1946 (Bloch and Purcell) Nuclear Magnetic Resonance.
1946 (Villard, Helliwell, Manning) Reflection of Radio Waves from Meteor Trails.
1947 (Hansen) Linear Electron Accelerator.
1947 (Field and Pierce) Traveling-Wave Tube and Backward-Wave Oscillator.
1948 (Ginzton and Chodorow) High-Power Klystron.
1954 (Motz) Millimeter-Wave Generator.

In addition Dr. William Shockley, former Palo Alto resident, developed the important Transistor in the East in 1948. These electronic developments, some of which we shall examine in more detail, indicate a close tie-in of industry and research in this field.

Instruction in electronics at Stanford really began in 1924 in the attic above Dr. Ryan's office—the same place where Cyril Elwell carried on some of his early experiments. This "Communications Laboratory," as it was then called, became under Dr. Terman the center of electronics at Stanford from 1924 until the end of World War II. Here it was that Bill Hewlett developed the Resistance-tuned Oscillator that became the basis of the Hewett-Packard Company. This became the "hangout" of others such as Dave Packard, Noel Porter, Noel Eldred, now sales manager of Hewlett-Packard and president of Palo Alto Engineering Company, Myrl Stearns, general manager of Varian Associates, John Kaar and Nathan Hall, now vice-president of Hughes Aircraft, who started ionosphere work at Stanford.

Harris J. Ryan High-Voltage Laboratory, famed for early-day research in power transmission and insulation, the scene of dramatic man-made thunderbolts.

Among the present Stanford faculty members who spent time at the Communications Laboratory while students are Doctors Ginzton, Villard, Pettee, Manning, and Helliwell, as well as William Ranbo and Robert Buss of the Stanford Applied Electronics Laboratory.

Important in the history of electronics at Stanford was the basement laboratory of the Physics Corner where Dr. William Webster Hansen, theoretical and experimental physicist, encouraged the Varian brothers in joint research with him. This yielded the important Klystron tube, making microwave radar possible and helping to win World War II. In one of the two laboratories named after him, Dr. Hansen eight years later developed the amazing Linear Electron Accelerator (atom-smasher). He died in 1949 at the age of 39.

Older residents of Palo Alto may be familiar with the noted Harris J. Ryan High-Voltage Laboratory with its six pairs of 115-foot towers and its network of wires strangely perched on one of the ridges back of the Stanford campus. It was opened in 1926 under the direction of Professor Ryan, world authority in this field and then head

of the Electrical Engineering Department. Gentle, little "Paddy" Ryan was called the "modern Thor" by feature writers; his technology produced the terrible ripping flashes of man-made lightning. In pioneering long-distance power transmission he had such trained laboratory specialists as Dr. William G. Hoover and Dr. Joseph S. Carroll, director of the Laboratory since Dr. Ryan's retirement. The great power-transmission lines from Boulder Dam were designed with the aid of Ryan Laboratory research.

The newer Science Quadrangle near the Physics Corner of the outer Quad on the Stanford campus includes three significant electronics-physics laboratories. They are the 1954 W. W. Hansen Laboratories of Physics, comprising the High-Energy Physics Laboratory and the Microwave Laboratory; the 1951 Electronics Research Laboratory (with the Hewlett-Packard and the Gilfillan wings), and the 1954 Applied-Electronics Laboratory. Dr. Edward L. Ginzton directs the Microwave Laboratory, and Dr. W. K. H. Panofsky is head of the High-Energy Physics Laboratory.

Dr. Frederick E. Terman (Stanford, A.B., 1920, EE., 1922; M.I.T., Sc.D., 1924, under Dr. Vannevar Bush) is the son of Dr. Lewis M. Terman, Stanford professor famed for his Stanford-Binet "IQ" tests and continuing studies of gifted children. Like his father, Dr. Terman was elected to the National Academy of Sciences in 1946. His appointment as an instructor in Electrical Engineering in 1925 began his 30-year career on the Stanford faculty. On leave during World War II, Dean Terman headed a staff of 800 scientists and technicians at Harvard University for the Office of Scientific Research and Development, chief United States agency producing radar counter-measures. He was decorated by Great Britain in 1946 and two years later received the highest U.S. civilian award, the Medal of Merit. Working with Dr. Terman at the Harvard laboratory was Harold F. Elliott, who designed machines for production of aluminum strips (chaff) to drop

Dr. Frederick E. Terman, Provost of Stanford University, Dean of Engineering, godfather of electronics at Stanford, winner of the distinguished Medal of Merit, highest U.S. civilian award (left).

Dr. William Webster Hansen, first director of Stanford University's Microwave Laboratory. Remembered as an electronics genius, he originated the modern form of electron linear accelerator, shown here with first section of Stanford's accelerator ever built. His portable oxygen tank, self-designed to sustain him for continuing research until his untimely death, inspired and saddened friends and associates (right)

from aircraft to confuse enemy radar. Elliott (Stanford, M.E. 1916, E.E. 1925) was chief designing engineer for transmitting equipment at the old Federal Telegraph Company (1918-24). His work on broadcast receivers led to the development of the micro-synchronous radio receiver, which was purchased by Victor and manufactured by R.C.A. in 1929 (record volume of radio sets produced). He also developed the clock radio built by Motorola. Though now retired, Elliott continues active in free-lance work and serves as consultant with the Hewlett-Packard Company.

Development of the Nuclear Magnetic Resonance in 1946 by two scientists, working independently with different methods, won world acclaim and finally joint award of the 1952 Nobel Prize in Physics. While Dr. Edward M. Purcell was making his discovery at the Harvard Laboratory, Dr. Felix Bloch was working closely with

Dr. Hansen at Stanford's microwave laboratory, and devised a method for measuring magnetic properties of atomic nuclei. This basic relationship involves the binding force "cementing" atomic particles. It was indicated by the influence of nearby magnetic fields in "tipping" the irregularly spinning unbalanced nuclei of atoms in particular pattern clusters in molecules of the element or compound being tested.

Dr. Bloch was honored again in June, 1954, when he was named director (recently resigned) of the 12-nation European Nuclear Research Center at Geneva, Switzerland, by the United Nations' European Council for Nuclear Research.

The powerful Linear Electron Accelerator, developed by Drs. Hansen and Ginzton in 1947, opened new horizons. Their 12-foot pilot model atom-smasher was followed by the microwave laboratory development of a 220-foot "gun" powered by 22 klystrons to produce an anticipated billion electron volts (actually only 675,000,000 to date, but the highest electron energy ever developed by man). The goal was bombardment of the center of the atom with a stream of electrons, leading to a closer understanding of the fundamental nature of matter, possibly the eventual creation of matter—protons and neutrons of the atom's nucleus.

Dr. Hansen felt this might lead to production of an artificial source of radiation comparable to the cosmic rays from outer space. Whereas the cyclotron accelerates the heavy, positively charged parts of an atom in an expanding circle, the linear accelerator shoots the lighter negative particles—the electrons—in a straight line in a dizzying "surfboard ride" through the accelerator tube on the crest of a radio wave. By the trip's end, at the mouth of the tube, electrons gain 2,000 times more weight (adding mass according to Einstein's Theory of Relativity), the electron "bullets," streaking at nearly the 186,000-miles-a-second speed of light, crash into the heart of atoms, knocking 15 to 20 particles out of each nucleus.

Dr. Von R. Eshleman operates this giant meteor-tracking "Spider" at Stanford for radio communications and weather research.

Wartime discovery of the important Traveling-Wave Tube and of the Backward-Wave Oscillator was made by the British scientist, Dr. R. Kompfner of Oxford. Research in these developments, begun in this country by Dr. John R. Pierce of the Bell Telephone Company Laboratories with Dr. Lester M. Field, formerly professor of Electrical Engineering at Stanford, continued in both the Stanford Research Laboratory and the Bell Laboratories. Outstanding success in these studies was announced here in 1947.

SKY "SPIDER"

Stanford's research, begun in 1946 in electronic communications, utilizing the stratosphere and ionosphere, is under the direction of Dr. Oswald G. Villard, Jr. at the Stanford Electronics Research Laboratory. His research team includes Dr. Robert Helliwell, L. A. Manning, and Allen M. Peterson. This post-war study investigated behavior of the Northern Lights and has involved a basic sky-communications process of sending out electronic waves which bounce off meteor dust trails at 50 to 70 miles up. These trails then ionize and reflect the signals down to distant receiving stations around the world. Sponsored also by the Air Force Cambridge Research Center, Stanford's Radio Propagation Laboratory on a hill back of the campus features a strange sky-

High-Energy Physics Laboratory at Stanford University.

pointed radio net, or "Spider," operated by Dr. Von R. Eshleman and Thomas V. Harroun. The "Spider" beams upward signals in six directions as it sweeps the sky to "trap" ionized meteor dust trails (10 billion stardust particles hit earth's atmosphere per day), comprising a reflecting "blackboard" of ionized air from the burned-out meteor flecks. This closer reflection of radio signals doubles or triples capacity of high-frequency radio channels for transmission of 1,000 miles or more as compared with the high frequency channel straight-line reflection from the ionosphere.

"SEEING" THE ATOM

Dr. Hanz Motz' invention of the Millimeter-Wave Generator at Stanford University's Microwave Laboratory in 1954 "looked" into matter itself! It filled a spectrum gap by providing frequencies between microwaves and infra-red rays. Dr. Motz' device permits the waves, oscillating up to two trillion times a second, to explore the "dark continent" of the atom world, thus permitting the scientist to "see" hitherto concealed events which take place only one-half of one trillionth of a second apart. Man-made electromagnetic waves vary considerably in length—from hundreds of miles down to infinitesimal sizes; the waves from 15 miles to about 30 feet long being used in radio, shorter ones being needed for television, radar, and microwave instruments.

ELECTRON MICROSCOPE

Dr. Ladislaus Marton, the Hungarian scientist (University of Zurich), shared recognition with Cornelis Bol at Stanford's 50th Anniversary program in Memorial Hall in 1941 because of his development of the Electron Microscope. In 1932, at the University of Brussels, he was working on the idea that an electron stream, instead of light, might be used to illuminate microscopic specimens; six years later R.C.A. Research Laboratory in Camden, New Jersey, brought him to this country, commissioned to design a marketable electron microscope. In 1940 said instruments sold at $9,500 each.

A $65,000 grant to Stanford by Rockefeller Foundation brought Dr. Marton here for a five-year research program. Development of the electron microscope involved electronic fields focusing electron beams to give 100 times enlargement, coupled with another magnetic lens increasing to 250 times more, or 25,000 times magnification. This enlargement received on a fluorescent screen is photographed and increased to a final magnification of 100,000 times (contrasting with optical microscopic magnification of only 2,000 to 3,000 times).

THE "INSIDE" LOOK

Since Dr. Paul H. Kirkpatrick, Stanford physicist, pioneered the University's X-ray Research Laboratory development of the X-ray Microscope in 1948, Dr. Howard H. Pattee, Jr. has continued research under his direction since 1953 in developing the experimental concept of a Scanning X-ray Microscope. The laboratory, first supported by the Research Corporation of America, has had the backing during the past several years of the American Cancer Society. In this new field of X-ray microscopy, Dr. Pattee (Stanford 1948, Ph.D. 1953) has been working on the principle that X-ray tube-scanning of live tissue or specimens with a point source of X-rays may be linked with a kinescopic display on which appears the magnified image (much like a closed-circuit TV system using a "flying spot" scanner). He hopes the scanning microscope idea may evolve into a useful tool in fundamental biology, metallurgy, chem-

istry and medicine. Its advantages would be a great range of penetrating power, higher resolution and magnification than a light microscope though less than an electron microscope, absence of heat and vacuum harmful to specimens, and permitting chemical analysis by absorption.

ELECTRONICS VETERAN

The Johnson-Williams, Inc., business, started in Oliver Johnson's small garage at 430 Tennyson Avenue by a pair of Stanford graduate engineers in 1927, is really the oldest local electronics firm. Their main product, marketed the world over, is combustible gas-detection equipment. Oliver Johnson and Philip S. Williams were working for Standard Oil Company when they were urged to figure out a way of detecting combustible and noxious gases of hydrocarbons or volatile oils in the big tanks. Their research for this important safety device took place in Johnson's garage, where their first "Gas Sniffer" was built. The firm later developed an Odormeter to detect smells for the Oronite Chemical Company.

The partnership for production of gas-detector equipment weathered the depression, withstood competition from a big eastern manufacturer of similar apparatus, occupied a little alley shop behind Paddleford's for eight years and in 1946 moved into the present plant at 2625 Park Boulevard,

Kenneth W. Johnson and Philip L. Williams carry on production of "gas sniffers"—oldest Palo Alto electronics firm founded by their fathers, Oliver S. Johnson and Philip S. Williams, in 1927.

Dr. Gerhard R. Fisher demonstrating his M-Scope's wizardry in detecting metal or water even 20 feet underground

Palo Alto. Today, its expanding $200,000 yearly gross business reflects orders from local industry to far-away places. Their yacht-model gas detector, for instance, was used in the Hal Roach TV Studio production of "On the Waterfront."

The Johnson-Williams firm is very much a product of Stanford men, the founders being Stanford engineers as are Cliff Woodhams, former plant manager for some years, and their sons Kenneth W. Johnson and Philip L. Williams, now actively directing the business while their fathers continue working on their other jobs.

FISHER RESEARCH LABORATORIES

Dr. Gerhard R. Fisher, who made the "divining rod" go scientific with his famed invention of the M-Scope here in a little garage shop at 1505 Byron Street in 1928, was drawn to America in 1923 by friends at Princeton University. This German-American engineer (University of Dresden, '23) worked for the de Forest Company in New Jersey and then became chief engineer with the Priess Radio Corporation of New York. In 1926 he accepted a Federal Telegraph Company job with Dr. Frederick Kolster as

radio-development engineer, specializing in radio-compass and direction-finding equipment and, with little money in his pocket, chugged all the way to Palo Alto on an old motorcycle.

Shortly after Fisher had become a United States citizen in 1933, the world learned of his (1929 invention) development of the noted radio direction-finder which Lt. Comdr. H. V. Wiley installed on the dirigible USS Macon as a homing device for its brood of scouting planes at nearby Moffett Field.

Today Dr. Fisher heads the Fisher Research Laboratories, Inc., a $700,000 electronics firm (from a $350 start in 1936) which combines research, manufacture, direct- and distributor-selling plus its own retail store beside the plant at 1961 University Avenue near Bayshore. This firm, family- and employee-owned (brother Curt, brother-in-law George MacLeod, and son Carl work there), independent of bank or government loans, is yearly inspected by Stanford commerce students who study it as a showcase of a highly successful small business.

The Geiger Counter and Scintilla-Scope duplicate for prospecting what the M-Scope performed in locating wartime land mines and searching out 20-foot deep pipe lines and water leaks. The Bendix Aviation Corporation, of North Hollywood, recently bought the company's Marine Division and direction-finder patents for $200,000. An annual thousand-dollar scholarship fund is given to Stanford students in the geology and geophysics departments, plus aids to research or foreign exchange scholars.

And Dr. Gerhard Fisher continues pioneering. This holder of 19 patents, who logged 28,000 miles flying in the dirigible Macon, leader in the Palo Alto Chamber of Commerce, and hobbyist in raising orchids, stamp collecting, and oil painting, now has his eyes on the last great Western frontier up north. In the resources-rich Dominion of Canada, Fisher Research Laboratory of Canada, Ltd., was established in Vancouver, British Columbia, only three months ago.

INVENTOR KOLSTER

Frederick A. Kolster, a native of Geneva, Switzerland, came to Palo Alto in 1921 to join the old Federal Telegraph Company as chief research engineer for production of his 1913 invention of the radio direction-finder to make men safe on foggy seas (Byrd Anartic Expedition used his radio compass).

Kolster earned his way through Harvard University and worked for the Stone Telegraph Company and for Dr. de Forest's firm for two years before entering government service (1912-21) as head of the radio department he organized for the Bureau of Standards at Washington, D.C. Back in 1913 he got the Bureau of Light-

Frederick A. Kolster, electronics pioneer, inventor of the Radio Direction-Finder

houses to place radio beacons at all important lighthouses and lightships and later influenced needed legislation for federal control of radio communications.

By 1925 Federal Telegraph Company began production of the Kolster Radios, radio broadcast receiver sets designed by the inventor. The big parabolic reflectors used by Dr. Kolster in 1928 for his experiments with directional antenna systems using short waves, including the unidirectional antennas, led to later developments in microwave directional transmission. He invented also the Kolster Decremeter for measuring electrical waves.

Kolster, who would have preferred being a civil engineer, lived on Kingsley Avenue with his wife and two daughters, Muriel and Fritzie, until 1931. He returned to the East when the Federal Telegraph Company moved away. After his wife passed away he moved to San Francisco's Bohemian Club. Shortly before his death in San Francisco in July, 1950, he had designed a television and radio antenna. His daughter, Muriel, acquired an engineering degree and worked for an aircraft company.

MOBILE TWO-WAY RADIO TELEPHONE

John M. Kaar believed that people ought to be able to communicate from moving vehicles (cars and boats). So this Stanford graduate developed radio intercommunication systems for taxicabs, police squad cars, harbor boats, etc.

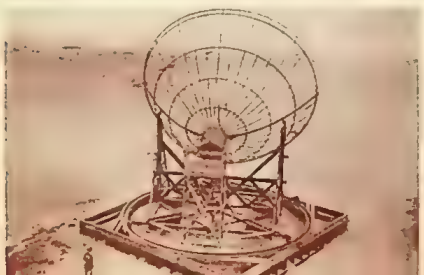
From the bedroom and garage radio repair shop of college years in Menlo Park, Kaar moved his business to 439 Florence Street, Palo Alto, in 1936, took larger quarters in the old Hupmobile Agency at 619 Emerson, and added three more downtown locations as his work expanded. His first mobile intercommunications order was to install a receiver in Gerald Dalmadge's dog wagon to hook into the local police radio net! Kaar recalls that his first big contract called for radio transmitters for Sierra snow plows called the "snow gos." In the war years Kaar Engineering Company handled highly classified orders in radar development for Sperry Gyroscope Company. A sizeable factory was acquired in 1947 when production was moved into the old Hammer Mill plant used by the Jack Heintz Company, by the Briarwood Pipe Corporation, and by Stanford for training aircraft workers. There, in this 35,000-square-foot plant, at 2995 Middlefield Road, the firm's 60 employees were doing the largest radio-telephone equipment business in the West.

John M. Kaar who developed mobile two-way Radio Telephone

In September, 1952, Kaar sold his electronics factory to Pacific Associates, Inc., a San Francisco investment organization, to gain enough added capital to triple production, remaining as vice-president with a one-sixth interest. Kaar Engineering was given the largest contract for medium-frequency communications equipment in this state—some 400 units for civil-defense communications in key areas. Factory output includes, besides two-way radio telephones for all important mobile bands, two-way marine radio-telephones, marine direction-finders, and station equipment.

Meanwhile, Frank J. Bella, a former employee, joined Kaar in a partnership in a next-door firm known as Western Coil Products, Inc., in 1952, with 20 workers to produce the Crown Marine Short-Wave Converter and other electronic items.

Huge parabolic reflector used by Dr. Kolster in 1928 for research with short-wave directional antennas resembling today's big revolving radar antennas (Photo courtesy Electrical Communications).



VARIANS BUILD THE KLYSTRON

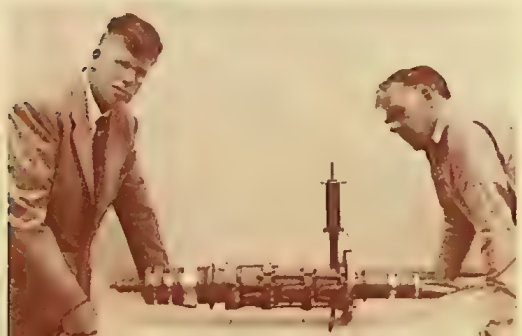
There's a gleam in the eye of Sigurd Varian as he shows you a copy of the

Palo Alto Times front page for January 29, 1939. On it are bracketed pictures of the Varian brothers and their Klystron announcement with smug Adolf Hitler and his Reichstag address warning the rest of the world he would "tolerate no interference" with his designs. News of the revolutionary microwave radio tube Russell and Sigurd Varian had developed and successfully tested at Stanford University—the "audion tube" of radar—appeared in the newspapers and journals of the world. And it was microwave radar, made possible by the klystron, which turned the tide against the dictators.

Throughout World War II the scientific and technological work of the Varian brothers was mobilized entirely for national defense. Thus it was 1948 before they could realize their schoolboy ambitions to establish their own laboratory for creative techniques in applied physics. Nucleus of Varian Associates, incorporated two years later, included, besides the two brothers, Edward L. Ginzton, H. Myrl Stearns, Donald L. Snow, Fred L. Salisbury, the late William W. Hansen, and Mrs. Russell (Dorothy Hill) Varian. In four years the firm grew from a single small building in San Carlos to an enterprise with a payroll of over 500, with annual sales exceeding $4½ million, and seven buildings plus a million-dollar research laboratory under construction on six acres of leased Stanford land in South Palo Alto.

By 1955, Varian Associates had 700 employees, yearly sales volume had mounted to $7 million, and a new $260,000 Special Products wing was being added to the Palo Alto research and development plant at 611 Hansen Way. Company stock was made available to the public for the first time on June 16, 1955.

Russell (left) and Sigurd Varian, with an early model of their famed Klystron, developed in 1939



Meanwhile two subsidiary firms had been added. Russell Varian's invention of the Earth's Field Magnetometer, a geophysical device to aid in seeking deposits of oil, iron, etc., from a plane overhead, fostered formation of Hycon Aerial Surveys, Inc. In 1954 the company also established Varian Associates of Canada, Limited, for the production and development of klystrons in a new $400,000 plant to be completed this year at Georgetown, Ontario.

Besides producing over 200 kinds of klystron tubes, Varian Associates have been making the tube with power-supply systems, pioneering in radio-frequency spectroscopy, and developing commercial instruments based on nuclear resonance. Nuclear-resonance apparatus is used for precise measurement and control of powerful magnetic fields, as in cyclotrons, and for performing certain qualitative and quantitative chemical analyses with great speed, economy, and flexibility —with special significance for industries concerned in moisture-content of food, plastics or petroleum.

"Klystron" is a name derived from a Greek word meaning "a thing in which waves break as on a beach," describing the wave-like pulsing movement of the rushing electrons. Applying the "velocity modulation" principle, the klystron actually passes a stream of electrons through a hollow resonator containing an alternating electromagnetic field at very high frequency. The electrons are alternately hurried or slowed down so that the fast ones catch up with the slow ones ahead to form clusters of electrons from which high-frequency energy can be extracted. The klystron tube, whose experimental models Sigurd built by hand, generates strong, stable microwave frequencies capable of being focused like a searchlight, allowing enormous economy of power, freedom

from atmospheric disturbances, and privacy of communications systems. The "boomerang" quality of the microwave beam is the actual basis of radar; bounding back from its object with the speed of light, the beam gives infallible information of the character of the object despite darkness or clouds (blind-landing guide, absolute altimeter, storm-front warning for pilots). The klystron has also prime usefulness in the television-relay link as the amplifier of the world's largest ultra-high-frequency television transmitter. It is also a laboratory device for measuring time and the velocity of light with extreme accuracy.

Emigrating from Ireland, the Varian family settled in Palo Alto in 1902. An Irish-American great uncle of lanky Russell and Sigurd Varian had invented the photolithographic printing and blueprinting processes. The boys' parents were John Varian, a hobbyist in Irish harps and a popular masseur who cheerfully entertained customers with commentary on Irish politics and history, and Agnes Dixon Varian (early-day Theosophists here). Their three sons branched into separate careers until electronics experiments drew Sigurd and Russell together at Stanford's electronics laboratory, under the wing of Dr. Hansen. Younger brother Eric became an electrical contractor in Halcyon.

Russell, the studious older brother, the "idea man," kept on with his studies in physics and experiments in electronics. But Sigurd, the adventurer of the family, worked for California Edison Company as a lineman in the high Sierra, became a barnstorming novice pilot of a wartime Jenny, and established his own flying school in the desert near Indio. He later joined Pan-American Airways as the first pilot to begin service to Mexico and Central America. A forced landing in the Mexican jungle only ten days after his honeymoon, and night-landing scares, made him concerned about the need for better safety instruments for fog and blind night flying. Threat of night bombing by the European dictators called for action. And Sigurd, the towering Varian brother, man of action, dramatically by-passed a Pacific Clipper command job awaiting him to join Russell in the exhausting and seemingly endless laboratory experiments on the Stanford campus, the baffling electronics trail toward radar.

At last, their 27th experimental idea clicked—the Klystron!

HEWLETT-PACKARD, ELECTRONICS GIANT

In the multi-billion-dollar electronics business of our nation, the 17-year-old Hewlett-Packard Company is already a veteran but still growing giant. And it all began in 1938 with two Stanford engineering students possessed of talent, on-job experience, $538, a garage to experiment in, and a dream.

Four years earlier this pair of young electrical engineers had laid their plans before Dr. Frederick F. Terman, who cautioned them to obtain additional work experience and knowledge before plunging into the business world. This they did; Bill Hewlett took graduate work at Stanford and M.I.T., and Dave Packard went with General Electric in the East. Their original one-car garage laboratory was located at 376 Addison Avenue when Bill Hewlett moved into a garden cottage in the rear of the plain brown-shingled house where the Packards had set up housekeeping.

First gadget sold was a diathermy

William R. Hewlett (left) and David Packard, Stanford engineers who founded world's largest electronics instruments firm

Hewlett-Packard Co. "complex" of ultra-modern administrative offices, laboratory and plant, Palo Alto

machine for the Palo Alto Clinic. They put together a thyratron drive to allow accurate setting of a telescope for Lick Observatory. They invented an electronic device for tuning harmonicas, a foul-indicator for bowling alleys, air-conditioning controls, and even an electric-shock-reducing machine for obese people. But it was Bill Hewlett's electrical engineering thesis on the Resistance-tuned Oscillator that hit pay dirt when it was presented at the 1938 I.R.E. meeting in Portland and brought in an order for nine units for Walt Disney Studios' stereophonic sound production of "Fantasia." It was the firm's initial "big order," and the following January the partners flipped a coin to determine the order of their names for the Hewlett-Packard Company then formally organized.

Outgrowing the garage laboratory, their business was moved in 1940 to a small rented building on Page Mill Road. Within another year they added an audio-signal generator, other audio oscillators, and a distortion analyzer to their output as the Armed Forces took note and government orders began coming their way. Plant size was doubled by a new building in 1948, and a twin structure was added in 1951 as a complete line of waveguide "plumbing" added to their products kept sales climbing and nearly 500 employees had the factories humming with a resumed two-shift operation. This was also the year (1951) that Palo Alto Engineering Company was launched at 440 Olive Avenue by several scientists at Varian Associates for production of transformers, reactors, inductors, coin-winding bobbins, and other electronic items.

Three years later Hewlett-Packard products had surpassed the million-dollar-per-month mark and assumed a position of dominance in the field of electronic measuring instruments. Over 225 instruments made the firm's "hp" line the world's most complete.

In 1953-54 more factory space was added, and the new 44,000-square-foot, $500,000 administration building was finished. This beautiful office unit, with ultra-modern "saw-tooth" glass skylighting, electrostatically filtered, air-conditioned, and sound-engineered, completed the present 140,000 square feet of laboratory, factory, and administrative units on an eight-acre site. The Hewlett-Packard firm, with a present payroll of 700, has reached a yearly sales volume of 12 million dollars.

Gift of the Hewlett-Packard wing at the new Stanford Electronics Research Laboratory, scholarship funds, employment of the handicapped, and a generous employee bonus plan indicate basic appreciation for human values of this firm. Electronics pioneer Cyril F. Elwell, special consultant, and Noel Edmund Porter, plant manager, and now mayor of Palo Alto, are only two of many key persons who have contributed importantly to this electronics firm's success. In the partners' participation in community interests, towering Dave Packard is a member of the Palo Alto Board of Education and was recently named to the Board of Trustees of Stanford University. Bill Hewlett, former member of the Palo Alto City Council, served also as president of the important 40,000-member Institute of Radio Engineers (he and Dean Terman being the only Westerners to share this distinction).

GENERAL ELECTRIC LABORATORY

On November 17, 1954, General Electric Company began operations in its new Microwave Laboratory at 601 California Avenue, third of three units across the country in its electronics division. Today the $320,000 plant on six acres of leased Stanford land is in busy operation with a team of 40 scientists and 65 supporting personnel directed by Manager Homer R. Oldfield, Jr., the scientist who organized and guided for two years the similar industry-university teamwork electronics plant at Cornell.

The purpose of the General Electric Microwave Laboratory at Stanford is basic research applied on electron-tube microwave lengths at high frequencies. Close liaison between the big company and Stanford is reflected in the Honors Cooperative Program for young electrical engineers of promise to pursue graduate studies with the firm assuming half of the tuition plus salary. Sixteen of the 40 General Electric Company scientists here are now or have been closely associated with electronics at Stanford University in graduate study, or as members of the faculty. Dr. W. A. Edson, of the G.E. laboratory, for example, is acting professor and research associate at Stanford's Electronics Research Laboratory.

Actually the G.E. laboratory embraces an aggressive program of microwave work and microwave tubes which, a spokesman declares, "promises to revolutionize the broadcast, communications, and radar industries over the next ten years." The research emphasized conception and development of new and improved microwave tubes of all types and power levels—high-power traveling-wave tubes, high-power klystrons, microwave oscillators, low-noise traveling-wave amplifiers, and low-frequency traveling-wave tubes.

ADMIRAL CORPORATION MOVES IN

Since 1952 Admiral Corporation has been operating a modest laboratory at 550 College Avenue, Palo Alto, under the direction of Robert M. Jones. Research centered on color television with resulting output of the firm's $895 color TV set.

Admiral Corporation, regarded as the world's largest television manufacturer, broke ground for its $175,000 laboratory on a three-acre leased site at Stanford Industrial Park on September 16, 1955. While development of color TV will continue in the new laboratory, according to company officials, important emphasis will center in research and development in guided missles, radar, air navigation and communication. This will be the initial Western plant of the big electronics producer of radios, television sets, refrigerators and other large "white goods" apparatus. The new laboratory may later be quadrupled in size to 60,000 square feet. With home offices in Chicago, Admiral Corporation has 10 factories across the nation which last year produced nearly a quarter-billion dollars output. The firm anticipates building 12 percent of the industry's expected output of 7,500,000 TV sets in 1955.

HOOVER TOWER'S "SUN SPOT"

Dutch physicist Cornelis Bol, developer of the world's brightest lamp, the water-cooled high-pressure mer-

General Electric Co. Microwave Laboratory at Stanford Industrial Park

Dutch Scientist Cornelis Bol with his powerful mercury-vapor lamp. (A single Bol lamp, scarcely larger than a fountain pen, lights the big airport at Amsterdam)

cury vapor tube (little larger than a fountain pen), has been active in electronics research at Stanford where, with aid from General Electric Company, he engaged in developmental studies during World War II in high-pressure lamps, "cold" lamps for TV and motion pictures, and invisible light ultra-violet lamps. Bol lamps cast sheet light instead of spot light. Some were tiny therapeutic lamps used inside the body; others were used in photoengraving. He also developed the sodium vapor lamps like those used to light San Francisco's two great bridges over the Bay.

Physicist Bol's technician, Ray Whittern, recalls the dramatic public demonstration of the pair of seven-inch Bol lamps one Friday evening, October 3, 1941, rigged from the Hoover Tower balcony (14 stories up). It was an occasion for continued festivities and folk dancing at the Inner Quad in the week of celebration for Stanford University's 50th Anniversary. On that pleasant moonlit evening the lamp was turned on about eight o'clock and a great blue-white sheet of light swept the heavens as it was slowly turned downward till the immense glare illuminated the campus grounds. Folks over a mile away by the senior high school and beyond the Southern Pacific tracks discovered a sudden "daylight" by which they could read their newspapers out in the yard as moonlight simply vanished. When testing the lamps that Friday afternoon Whittern was startled by shadows produced in the face of sunlight by this lamp of 1,500,000 candlepower brilliancy (lamp: 200,000 candlepower per square centimeter; sun: only 160,000 candle power per square centimeter!).

STANFORD RESEARCH INSTITUTE

It is understatement to comment that electronics is important at the nine-year-old Stanford Research Institute laboratories in Menlo Park where a thousand people under the direction of Dr. Jesse Hobson are centered on significant industrial and governmental research projects.

Thomas H. Morrin, director of the Engineering Research Department, states that of S.R.I.'s total of $7 million for all developmental and research work in 1955, some $3 million alone was allocated for electronics projects. His special assistant in engineering research is Archibald S. Brown. Dr. Jerre Noe, William McGuigan, and Dr. John V. N. Granger are assistant directors in engineering, Dr. Granger heading the important continuing studies with antennas for military aircraft. Dr. Cledo Brunetti, former chief of the electronics section of the U.S. Bureau of Standards, played a leading role while an assistant director at S.R.I. in the development of printed radio circuits and the wristwatch radio.

The wide range of electronics projects at Stanford Research Institute has included not only the vital testing programs in the aircraft radiation systems laboratory but also color television, the precision-gauge laboratory development of the electrolimit comparator (instruments capable of one-millionth of an inch measurements, or about a thousandth of the thickness of a mosquito's wing), the electron microscope (permitting photography of "invisible" virus), video subminiature tubes for guided missiles, and many others.

S.R.I.'s recent announcement of ERMA, the 25-ton "whiz kid" electronics gadget destined to revolution-

Stanford Research Institute in only seven years uses a third of Stanford Village, Menlo Park, and has branch offices and laboratories on both coasts and abroad. Administrative offices and laboratories occupy the former Dibble General Hospital shown here.

ize bank bookkeeping and accounting, was sponsored by the Bank of America. ERMA takes coded checks, looks up the account, figures the new balance, and passes the information along to a magnetic tape for future reference. It automatically flashes a warning to the operator if the transaction results in an overdraft or if a "stop-payment" has been placed against the account. All this takes ERMA one-tenth of a second! The magnetic tape, with a running record of every account, is hooked up to her high-speed printer which whips out monthly statements or daily reports at the rate of 600 lines per minute!

An S.R.I. spokesman claims electronics is still in the horse-and-buggy stage. These scientists believe that about a decade from now they will be well started on the greatest revolution to hit American industrialization since the invention of the steam engine. It will be the invasion of commerce and industry by efficient, foolproof, compact, and low-cost electronics. Industrial radar will greatly influence civilian communication and transportation, while industrial television may make even business trips unnecessary. One scientist observed there is the possibility that "airplane travel will be used only by vacationists, government officials, and fugitives from justice."

PALO ALTO—ELECTRONICS HUB

Notable example of specialization in electronics is the Bennett Products Manufacturing Company, 815 San Antonio Road, Palo Alto, producers of hermetic seals for electronic outlets. This firm, headed by Richard E. Bennett, was launched in 1952 and now yields a $500,000 business gross. E. T. James is vice-president and Harry E. Judd, secretary-treasurer of this rapidly growing plant.

The Kaiser Aircraft & Electronics Corporation established its West Coast Electronics Laboratory at 850 San Antonio Road, Palo Alto, in December, 1954. The research of its 50 employees has been centered on study and development of cathode-ray tubes and related electronic circuits. M. L. Frank is administrative manager of the local laboratory. Nearby at 750 San Antonio Road is the Thor Transformer and Electronics, Inc., firm founded by Harold J. Birdsell in 1949.

Westlabs, founded in the fall of 1954, is a Palo Alto electronics organization with William R. Rambo as president, and William E. Ayer (both scientists at Stanford's Applied Electronics Research Laboratory) guiding the research and consultant services of this firm. Current work centers on production of broad-band microwave amplifiers, or traveling-wave tubes, for commercial application. Lacking its own laboratory-plant, the firm's work is done at home labs of employees.

Two other local electronics businesses started in 1954 are the Alto Scientific Company, Inc., founded by Thomas Turner, whose plant at 437 El Camino Way produces microwave equipment, and RS Electronics Corporation, at 435 Portage Avenue, builder of electronics testing equipment.

Unique aspect of the RS Electronics Corporation is that its establishment is the consequence of the Republican administration's policy change to turn business back to private enterprise. This firm was jointly founded in June, 1954, by the Electronics Division of the National Bureau of Standards, Washington, D.C., Department of Commerce, and the former Selective Cam Transmission Company (then in San Bruno) for research, development, and production of commercial and military products. Current work at this El Camino Way plant centers on production of sub-miniature intermediate-frequency amplifiers. The com-

pany is headed by George P. Regan, Sr., president, George P. Regan, Jr., vice-president, W. E. Regan, Jr., Secretary-treasurer, and Robert K-F Seal, vice-president and chief engineer.

NEIGHBORING ELECTRONIC GIANTS

Mountain View's pair of big Sylvania plants with 760 workers, established in 1953-54, is the Western extension of a national concern with 44 plants and 18 laboratories scattered across the country. The Sylvania Microwave Tube Laboratory and the Electronic Defense Laboratory, directed by Gerald C. Rich and Samuel A. Ferguson, had their local start in Mark Tuban's tin garage on El Camino in 1952. Humble beginnings of the parent firm can be traced back to 1901, when Frank Poor and his two brothers haunted the town dump at Salem, Massachusetts, to collect burned-out light bulbs to which they added new filaments and bases.

San Francisco is where Philo T. Farnsworth (1925-30) developed an all-electronic television system, where Ralph Heintz first achieved short-wave radio from ground to aircraft in flight, and where Federal Telegraph's pioneer Beach broadcasting station was built in 1910. The recent WESCON show, under Noel E. Porter's chairmanship, in San Francisco (750 exhibitors) was the country's second largest electronics show.

T. I. Moseley also wrote a bit of electronics history when he steered his San Francisco hardware firm into the electronics business about 1940, moved it down to San Carlos, where it prospered until his Dalmo Victor plant with 1,000 employees became the nation's leading designer and manufacturer of airborne radar antennas. The firm's current annual output of $15 million was topped by the 1953 peak of $30 million volume. Last year Dalmo Victor Company, for whom Allen S. Dunbar of Palo Alto is assistant chief engineer, was sold to Textron-American, of Providence, Rhode Island.

This spidery Transistor is starting an electronics revolution.

Another San Carlos firm, Lenkurt Electric Company, has 950 on its payroll and makes many types of telephone, radio, and telegraph carrier equipment. Litton Industries, with 800 workers there, is famous for research and manufacture of magnetrons. Counterpart of the Hewlett-Packard partnership is the Eitel-McCullough firm in San Bruno, world's largest manufacturer of transmitting tubes (910 employees); this was founded by Bill Eitel and Jack McCullough 21 years ago in a vacant butcher shop.

The unique Ampex Corporation, Redwood City's 750-employee electronics firm founded by Alexander M. Poniatoff in 1944 (at San Carlos), pioneered magnetic tape-recording equipment. Production of Bing Crosby tape recordings opened its nationwide field leading to a current output of over $8½ million.

ELECTRONICS MIDGET

In 1912 Palo Alto gave birth to radio, and 36 years later William Shockley, a former Palo Altan, revolutionized radio.

Remember the old crystal radio set and how one tinkered with a piece of galena (lead ore) crystal and a small "whisker" wire attached? Well, the amazing little crystal (now the rare germanium) has sneaked back again, this time with two spidery wires, a fresh name, and wondrous capabilities and possibilities—the Transistor.

Dr. William Shockley, with Dr. John Bardeen and Walter H. Brattain on his nine-man team, developed this powerful transistor in the Bell Tele-

Famous Scientists William Shockley (left) and Lee de Forest inspect each other's historic inventions, the Transistor and the Audion Tube.

phone Company Laboratories at Murray Hill, New Jersey, by 1948. He is a recognized authority in the field of the physics of semi-conductors. Like Dr. Terman, he was awarded the rare Medal for Merit, highest civilian award for distinguished wartime services. (This award and Purple Heart Medal were initiated by George Washington.)

Dr. Shockley is the son of the late Prof. William H. Shockley, who lectured in mining and metallurgy at Stanford in the early '20's, and Mrs. May Bradford Shockley, active member of the Palo Alto Art Club, who lives at 261 Waverley Street. Bill Shockley lived here from 1913 to 1922. He attended Palo Alto Military Academy, was at Stanford a short while, graduated from Cal Tech, and received his Ph.D. in physics from M.I.T. in 1936. He served as wartime consultant for former Secretary of War Robert Patterson and made important contributions for improving radar bombardment in the China, Burma, and India theater of operations.

The transistor really is a tiny metal cylinder scarcely larger than the tip of a shoelace. It acts instantly with nothing that lights, glows or warms up. It behaves like a radio tube but has no vacuum, no grid, no plate, no glass to keep air away.

"The transistor's entire innards," says a former AP science editor, "are merely two hair-thin wires that run down to the base of an empty tube to stand on a bit of metal not much larger than the head of a pin. This piece of metal is the secret. The metal amplifies the current that one wire carries to it, and the other wire carries away the amplified current."

Apparent simplicity veils incredible complexity in this "doctored" bit of wonder-performing germanium metal. Harland Manchester described in Science News Letter the strange performance of this metal. Dr. Shockley's Bell Lab scientists introduced meticulously measured impurities in ultrapure germanium which upset the metal's orderly atomic pattern, changing it into a restless structure full of submicroscopic holes and of homeless, wandering electrons. A current sent through this re-organized metal "touched off a complicated game of musical chairs as the holes moved like bubbles in a liquid and the loose electrons rushed to fill the empty places."

Controlling this distribution of holes and electrons, the scientist made the current perform various stunts. Sticking a tiny wire from a radio antenna into the metal, they forced the current to amplify amazingly. They no longer needed to "boil" electrons out of a metal plate as in a vacuum tube and so saved much fuel in the form of electric power. Transistors are not plugged, but wired in permanently, since they are expected to last and function indefinitely. Since 1948 over 30 big corporations have been vigorously competing to harness this mighty midget of electronics.

The westward movement of electronics, now America's third largest industry, is represented by 7,000 firms on the West Coast. Mayor Noel E. Porter, of Palo Alto, a Hewlett-Packard Company executive, noting the rapid expansion of this field observed "you can't lie fast enough to keep up with the truth." As a point of origin for electronics, Palo Alto has the historic distinction of being the "Menlo Park" of radio, communications, and electronics.

Here Palo Alto Historian Guy C. Miller worked faithfully to the day he died.

Integrating the sciences of mathematics, physics, chemistry, and electrical engineering, research teams' persisting exploration of this wondrous electronics frontier of God's universe, fashioned of forces within the atom, is limited only by the reach of man's imagination and humble belief in his own role of revealing and applying for the benefit of mankind the Creator's laws and realities of existence.

HISTORIAN GUY C. MILLER

In the death of Guy C. Miller in June, the Palo Alto Historical Association lost the man whose research inspired its organization, kept its work going, and left a priceless legacy of material on the community's background.

Although he was 78, Guy Miller was active up to the day he walked over to the hospital for the operation he did not survive. He had been busy that very morning with the collection he had organized and made widely useful in the basement of the Public Library. Some of the record which he helped amass is preserved in the 1952 **Palo Alto Community Book;** much has appeared in Hugh Enochs' seven yearly issues of **The Tall Tree.**

Palo Alto is richer for Guy Miller's contributions. His shoes can never be filled, but someone must be found to carry on the collecting and organizing of the continuing Palo Alto Story.

The Palo Alto Historical Association's sixth annual Memory Party was held January 22, 1955, in the large community hall of the First Methodist Church, of Palo Alto, with 450 members and friends attending. The Palo Alto Newcomers' Club assisted by serving refreshments, and Association President Dan C. Baker welcomed folks and then teamed with Cliff Q. Giffin, master of ceremonies, to show early-day slides. One-man-band Fred Hage and vocalist Marie de Forest entertained.

Mrs. William A. (Katherine Sheldon) Mudgett, assisted by Mrs. Dean W. Buchan, Mrs. Ray Whittern, Verona Price Jayne and others, registered members and guests. Mrs. Dolly Laramie, 94; Mrs. Lydia W. Bodley, 92, and John F. Parkinson, 90, were the senior members present. (Mrs. John Squires, 94, barely missed the party because of a cold). Among members attending the 1955 Memory Party the following had moved to Palo Alto by 1900:

Mrs. Frank Abbey, 1893; Mrs. Harold Beaver, 1893; Mr. and Mrs. Joseph G. Brown, 1898; Mrs. Dean (Lucile Huff) Buchan, 1897; Mrs. George J. Carey, 1897; E. B. Corbet, 1898; Lawrence E. Cutter, 1894; Paul and Bruce Gibson, 1895; Mrs. Paul F. Kerr, 1899; Edgerton D. Lakin, 1900; Mrs. W. Bruce McMillan, 1880; Guy C. Miller, 1897; Dr. J. Pearce Mitchell, 1896; Mrs. Frederick J. Perry, 1896; Burnett Sanford, 1891; Will C. Werry, 1887.

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